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TITLE

THE EFFICACY OF ROADSIDE PLOTS AS AN AID IN ESTIMATING CURRENT BARK BEETLE DAMAGE IN PONDEROSA PINE FORESTS

By

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Forest Insect Laboratory
Coeur d'Alene, Idaho
January 26, 1949

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January 28, 1949

To: F. C. Craighead, In Charge, Forest Insect Investigations

From: James C. Evenden, Box 630, Coeur d'Alene, Idaho

Subject: Report of Survey of roadside plots.

The enclosed report, entitled "The efficacy of roadside plots as an aid in estimating current bark beetle damage in ponderosa pine forests", is based upon work done by Mr. Johnson while on the staff of the Berkeley laboratory. His transfer to Coeur d'Alene occurred before the report could be completed. In view of this, and because of the possibilities in the field of bark beetle surveys dealt with in the report, an opportunity to complete it was afforded Mr. Johnson this past year. Though I believe he had in mind the bark beetle survey problem as it has existed, or exists, in the Pacific Coast States, I feel that the procedures proposed in the report might apply in parts of the Rocky Mountain region as well. Since we may be on the brink of a vastly augmented forest insect survey program I think we can all give serious thought to the methods which may be used. I look upon Mr. Johnson's contribution as a means toward this end. We both will be interested in comments you may wish to make on the report.

Encl.

CC: Berkeley Lab.
Portland "
Ft. Collins Lab.

THE EFFICACY OF ROADSIDE PLOTS AS AN AID IN ESTIMATING CURRENT BARK BEETLE DAMAGE IN PONDEROSA PINE FORESTS*

By Philip C. Johnson

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(*) The field work and basic computations for this report were made while the writer was assigned to the Berkeley, California, laboratory.

THE EFFICACY OF ROADSIDE PLOTS AS AN AID IN ESTIMATING CURRENT BARK BEETLE DAMAGE IN PONDEROSA PINE FORESTS

By Philip C. Johnson

INTRODUCTION

Bark beetle surveys carried out annually in the ponderosa pine forests of California, Oregon, and Washington have been both extensive and intensive in nature. The major difference between the two types is mainly in the degree of coverage. Extensive surveys, as the name implies, are rather superficial in nature. These have been used whenever (1) extremely large areas have had to be covered in a limited time with a small personnel, (2) timber values have not warranted more detailed work, or (3) the bark beetle infestations have been considered to be relatively insignificant.

Intensive surveys, on the other hand, have been conducted in such a way as to provide a more intimate knowledge of beetle infestations where the forest cover is important either commercially or aesthetically. Because of the greater values protection from beetles is usually an important factor in the management of these forest areas and a year-to-year knowledge of infestation conditions is almost a necessity. As a consequence, intensive surveys are most apt to be on an annual basis and this has been the case for many years in some parts of the ponderosa pine forests of the Pacific Coast States.

This has made it possible to use permanent or semi-permanent sample plots to sample the infestations in given areas. From these plots has come data which, in most cases, have provided more detailed information on the amount of timber damage, the trends of the degree of infestation, and the location and magnitude of any beetle control measures which have been needed.

The qualitative samples of the annual infestations provided by the plots over a period of years has been of increasing value from a research standpoint. Their greatest use, however, has been in supplying a basis for annual estimates of the quantitative timber mortality caused by bark beetles over relatively broad areas. Where plots have been comparatively numerous in areas of uniform stand and current infestation conditions a mortality estimate for the entire area for any one year has been almost an arithmetic process of simply multiplying the average mortality on the plots by the acreage of the area.

Where plots have been more widely distributed they have tended to become merely small islands of known mortality in a vast expanse of forest area. Estimating the mortality in the whole area then has become more difficult. If sufficient facts concerning the timber stands have been available -- stand volume, composition, beetle hazard, to name a few -- an estimate has been arrived at either by an arithmetic interpolation of the mortality values of the various plots in the area or by personal judgement.

For many years the sample plots used for this purpose have been rectangular in shape and usually 320 acres (one-half mile wide and one mile long) in size. The procedures used in the annual examinations of these plots have become fairly well standardized (1) (2). In brief, they call for a 3-man crew--one compassman-mapper and two spotters-- which systematically covers the entire plot area for the purpose of locating all currently infested trees. Each tree, as it is located, is mapped, blazed, given a serial number, examined for the species and brood development of the attacking beetle, measured for board-foot volume, and described by the degree of fading and the classification of the crown. At times supplementary information is obtained on the rate of growth of the green and infested trees, the volume and structure of the green stand, and other kindred information.

Each of these operations is essential and each has been fashioned as to take the least possible time. A serious objection to these plots, however, is the travel time of the field crew between infested trees. On plots where no infested trees occur, for instance, it takes the 3-man crew from 2 to 4 or more hours, depending upon topography, stand density, and ground cover density, merely to run the necessary compass lines and for the spotters to cover their respective strips. When, to this travel time, the time necessary to spot and mark the infested trees is added it means that, in most cases, not more than one plot per day can be covered by the crew.

This is a decided handicap to bark beetle surveys relying upon these plots because of the relatively great cost of examining them. Consequently, fewer plots can be used and these must be more widely distributed than the principles of good sampling dictate. To adequately sample the many thousands of acres of ponderosa pine forests where intensive surveys would be justified would require more plots than the funds normally allotted for this purpose in the three Pacific Coast States could underwrite. Determining just how many are needed is a problem in itself beyond the scope of this report. Suffice to say, the proper number depends upon factors which vary from one area to another so that its derivation must necessarily be a separate operation in each specific area.

The roadside plot was perfected in 1941 to help offset this objection by providing a sampling device capable of securing

essentially the same information as from the 320-acre plot yet with less manpower and over-all time. Roadside plots, as described later in this report, were first used in the 1941 annual survey of bark beetle infestations in Plumas, Lassen, Modoc, and Shasta counties, California. The initial installation of these plots by the writer was augmented in 1942 and has since functioned on a permanent basis. In 1942 also, Charles E. Eaton, then assigned to the Berkeley, California, laboratory, aided in certain refinements in the plot measurement techniques and in some of the first tests of their effectiveness. The following year John M. Whiteside and Walter J. Buckhorn of the Portland, Oregon, laboratory, assisted the writer in conducting field tests of the practicability and general usefulness of the plots in Lake County, Oregon and Modoc County, California. In that year, too, tests were made in Madera County, California to determine the adaptability of roadside plots in the rugged topography and dense stands of the western slopes of the Sierra Nevada mountains.

Certain advantages and some disadvantages of the roadside plot have been brought to light as a result of these tests. These are discussed in some detail in the paragraphs which follow. The report also includes a description of the roadside plot and of its possibilities as a part of bark beetle surveys in ponderosa pine stands.

THE ROADSIDE PLOT

Characteristics

The term "roadside plot", as used here, may be defined as a sampling unit made up of a narrow belt or strip of forested land contiguous to one or both sides of and paralleling a permanently located section of roadway. It should not be confused with such terms as "road counts" or "road strips" which have been used by forest entomologists to refer to a technique used in extensive surveys where only a rough count of infested trees is made along a road. Roadside plots are intended as permanent checks or samples of bark beetle infestations which may develop over a period of years on a definite area. Infested trees found during the periodic examinations of the plots are not only counted but carefully examined, measures, marked and mapped. The data thus secured should be sufficient, both quantitatively and qualitatively, to follow the course of year-to-year infestations on the plots. The chief value of these data, as previously mentioned, is their usefulness in estimating beetle-caused timber mortality over fairly large units of land of which the plot or plots are of but a small fraction.

Roadside plots are of predetermined width and length, hence of known surface area. They are most often quite irregular in shape

since the axis of the plot follows the center line of the meandering road which it parallels. The plots are precisely located even though their irregular shaped boundaries are not actually surveyed or marked except as they intersect the road at the beginning (Initial Point) and ending (Closing Point) of the plot (Figure 1).

Theoretically, the plots may be of any length as long as stand conditions remain uniform within the plot. Certain practical considerations, however, make it desirable (1) to limit the length so that more plots can be established over wider areas (better sampling) and (2) to standardize the length so that data from the plots is more directly comparable. Since portions of some plots may include non-forested or atypical forest acreage distinction is made between the net and gross lengths, and hence acreage, of the plots, providing that the timbered and non-timbered acreage is known in the area being sampled. Net length is the length, as measured along the road, of the portion of the plot to be cruised periodically for beetle-killed timber. The gross length is this length plus the length of any interruptions in timber type or portions of the plot not cruised (see Figure 1).

The width of roadside plots depends upon the ability of the spotter to see each individual tree, green or infested, as he rides slowly along the road which forms the axis of the plot. This, in turn, is governed by such things as (1) density of the stand (number of stems per acre, all species), (2) density and height of ground vegetation or tree reproduction, and (3) the cross-section topography of the plot. In theory, the thinner the timber stand, the sparser the ground vegetation and the flatter the land surface the wider the roadside plot can be.

In practice, roadside plots with a net length of 160 chains (2 miles) and a width of 10 chains (5 chains, or 330 feet, on each side of the road) have been found to be very satisfactory. A plot with these dimensions will be 160 acres in net timbered area.

Several considerations helped determine the selection of these plot dimensions. Perhaps the most important was the fact that a spotter searching for infested trees, as indicated chiefly by their fading foliage, can be expected to see no more than 5 chains away with any degree of accuracy in most ponderosa pine forests. Since the spotters work mostly from the road in their examination of roadside plots the outer margin of the plots ordinarily can be no further than 5 chains from the road. Experience has also shown that a 160-acre plot is estimated to be about the smallest plot which will adequately represent the rate of beetle-caused pine mortality in the surrounding forests during periods of normal or below-normal infestations. Finally, the 5-chain wide strip has been the principle

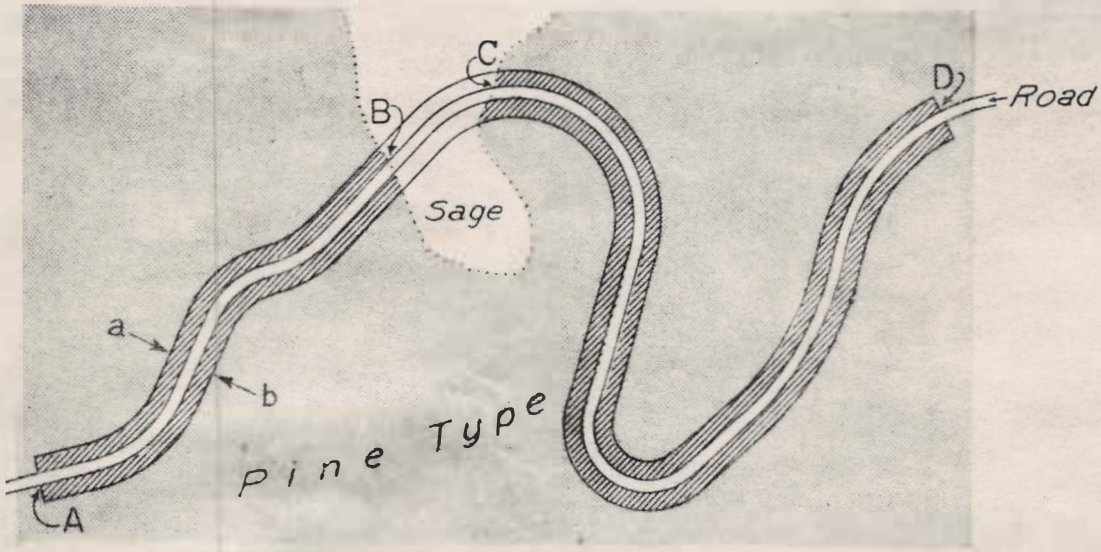


Figure 1. Typical roadside plot (indicated by hatching) in ponderosa pine forest type (indicated by stippling). Periodic measurements of beetle-killed pine trees are made in cruises beginning at the Initial Point (A) and terminating at the Closing Point (D). The cruise is interrupted in atypical parts of the plot such as that between B and C. Symbols indicate gross length, A-D; net length, usually two miles, A-B plus C-D; width, usually ten chains excluding width of road, a-b; and interruption or atypical area within plot, B-C.

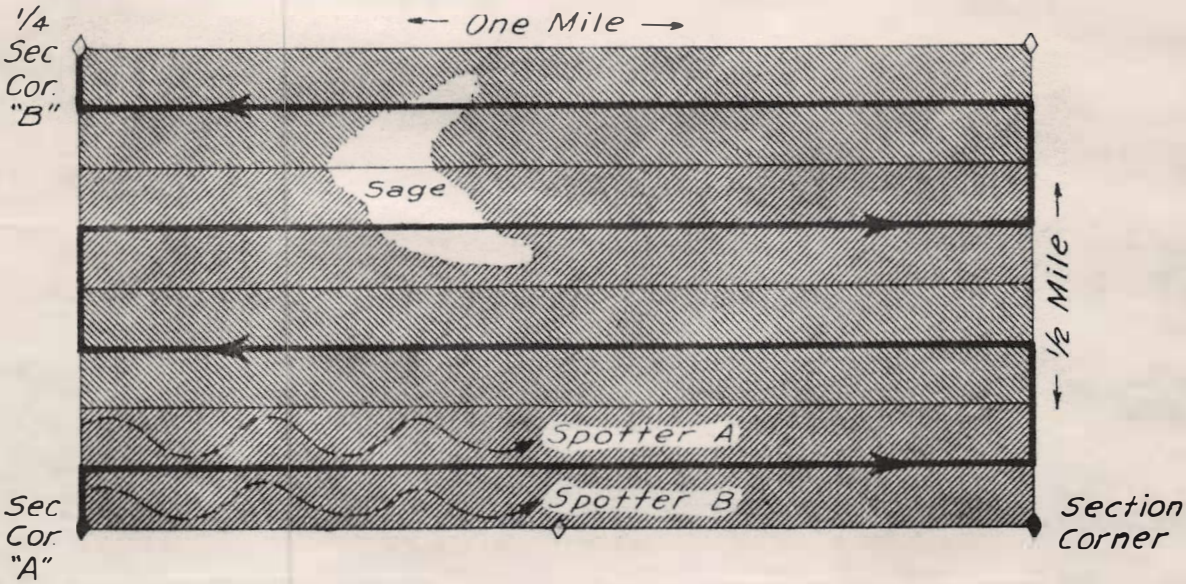


Figure 2. Typical 320-acre (half section) plot showing route of compassman (heavy black line) between Section Corner "A" and ¼ Section Corner "B", course of each of the two spotters (broken wavy line), and the four 10-chain strips (reversed hatching) into which the plot is divided.

component of the periodic examinations on the 320-acre rectangular plots for many years and it has been found that spotters can be easily trained to visualize this distance. This similarity, too, is helpful in summarizing the pine mortality measurements where both types of plots have been used. Comparisons of this kind have been used frequently later in this report.

Location and Establishment

The determination of the number and placement of roadside plots needed to adequately sample bark beetle infestations in a given forest area involves a number of considerations. Most important, perhaps, is that the plots should be representative of the stand and infestation conditions which they are to sample. Their number is determined largely by the uniformity of stand characteristics -- species composition, density, age, vigor, exposure, and elevation. In general, the more uniform each of these factors is over large areas, the fewer the plots which will be needed to sample them. This pertains not only to roadside plots but to any type of plot to be used for the same purpose.

A special consideration in the case of roadside plots, however, is the matter of forest roads. Since the roadside plots are totally dependent upon roads they cannot function unless there is ample road mileage distributed through representative portions of the stand. Furthermore, not every road can be used for a roadside plot even though it does traverse extensive timbered areas. The road itself, for instance, should not affect the vigor of the trees which border it or alter their natural susceptibility to bark beetle attack. For this reason, a study of existing roads should precede the establishment of roadside plots in any given area not only to determine the possible distribution of plots but to find which roads or sections of roads are most suitable for plots. Roads with the following characteristics have been found best for roadside plots:

1) Ungraded. Many old wagon roads laid out years ago by sheep and cattle outfits are ideal.

2) No right-of-way clearing, if possible.

3) Horizontal slope not excessive and horizontal and vertical curvature not too abrupt.

4) Isolated from man-made or other preventable disturbances to the bordering forest caused by heavy traffic and proximity to human habitations.

5) Accessible for periodic examinations.

When roads have been found which meet these specifications a trip or two along them usually is enough to determine which portion is most adaptable to the establishment of a roadside plot. The details of installing a plot have been worked out by actual trial and improved several times since the first installation of these plots in northeastern California in 1941. These are described rather fully in the Appendix. Briefly, they consist of fixing the initial and closing points of the plot, preparing a diagrammatic sketch of the road traverse between these two points, and recording basic information pertaining to the plot designation, location and description (Appendix Form 1). Even though the plot is apt to be quite irregular in shape these procedures make it possible to easily locate it in subsequent examinations.

Measurement Methods

The major difference between roadside and rectangular plots used in bark beetle surveys is the manner in which periodic measurements are made. Despite this difference the measurements yield essentially the same information and, therefore, the two types of plots can be used together in surveys of the same general area. In the periodic examinations of the rectangular plots the 3- or 4-man crews cover the entire plot area on foot by means of compass and pacing control. The plot usually is subdivided into 10-chain strips (Figure 2) which the crew covers in progressive order. The spotters keep abreast of the compassman as they follow a weaving course through their assigned portion of the strip in search of currently infested trees.

The 2- or 3-man roadside plot field crew, on the other hand, uses no compass or pacing control, but depends instead upon the road alignment and automobile odometer readings for determining their position in the plot. Instead of walking, the crew rides the entire length of the long, narrow plot in a slowly (5-7 m.p.h.) moving automobile. The spotter's duties are little changed over those he employed on the rectangular plot. He rides between points opposite the infested trees he finds. He must rely more upon visual evidence of beetle attack which the infested trees may exhibit at the time of the examination. He must concentrate more on his search for infested trees and learn to take advantage of every opening through the trees to view the more distant trees. In some respects, he can do this better, perhaps, than the spotter afoot since he need not watch the ground for footing or work his way through brush and tree reproduction. Though he has usually only a fleeting glance of each tree on the portion of the plot assigned to him -- usually the portion lying along one side of the road only -- he is privileged to signal the driver to stop at any time for a closer examination of any particular tree.

When a tree is suspected of being infested the spotter signals the driver to stop opposite it. The spotter then dismounts and paces out to the tree to complete his examination. If the tree is infested and on the plot he takes the information needed on his spotting record (Appendix Form 2). The driver, in the meantime, plots the location and number of the tree on a special diagrammatic form (Appendix Form 3) using a coordinate system based upon odometer readings from the initial point of the plot and the paced distance of the tree from the road. Thus the tree is accurately located with reference to the initial point. When the necessary information concerning the infested tree has been secured the spotter returns to the automobile, boards it, and signals the driver to resume forward travel.

This, in brief, is the routine followed in each examination of a roadside plot. A more detailed account is given in the Appendix along with certain precautionary measures in the design and use of automotive equipment to safeguard the spotting crew and to assure maximum visibility for the spotters.

THE RESULTS OF SOME EFFICIENCY TESTS

Spotting Accuracy

During July 1943 field tests were made in ponderosa pine stands on the Fremont National Forest, Oregon and on the neighboring Modoc National Forest in California to determine the spotting accuracy obtainable on roadside plots. Specifically, these tests sought to determine with what degree of accuracy spotters riding slowly along a road could find, or "spot", currently infested ponderosa pine trees within 5 chains of the road.

Two roadside plots of 160 acres each and 9 roadside plots of varying size, but totalling 1,170 acres, were selected for the tests on the Fremont and Modoc forests respectively. The field crew, consisting of one driver and two spotters, used the pickup truck shown in Figure 3. Each plot was cruised according to the procedure outlined in the preceding section entitled "Measurement Methods". After the plots were cruised the crew returned to the beginning of each plot and the spotters covered their respective plot strips afoot to locate any infested trees which might have been missed in the cruise made from the road.

The spotters in both instances were instructed to locate and mark trees killed in 1942 and those killed in 1943 up to the time of the tests (July). The 1942-killed trees were distinguished by their reddish or sorrel tops and abandoned broods. The possibility of including trees killed prior to 1942 was remote since these had

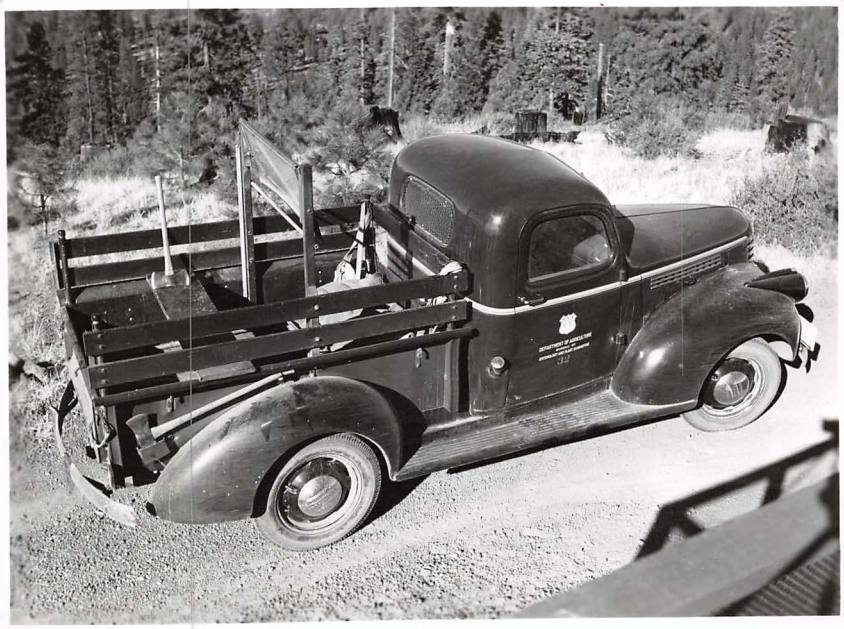


Figure 3. View of ½-ton pickup truck adapted for roadside plot surveys in northeastern California. Alterations designed to provide greater visibility and safety to the spotters included side rails, sliding seat board, auxiliary windshield and attached hand hold, and a rear bumper used as a step in climbing on or off the truck. Not shown is an auxiliary survey odometer mounted in the cab and calibrated in hundredths of miles.

During plot examinations the spotters ride either seated or standing in the bed of the truck. Most often they have preferred to stand on the seat while holding to the top of the windshield to give them a more uninterrupted view of the trees on the plot. (11617 B)

already been marked in preceding cruises. The 1943-attacked trees contained newly-developed broods ranging from eggs to half-grown larvae and bore faded crowns ranging from an almost imperceptible fading to a pronounced sorrel color.

The results of this test are shown in Table 1. Out of a total of 41 infested trees (38,180 board feet) found on the plots 38 trees (34,630 board feet) were spotted from the slowly moving automobile and 3 trees (3,550 board feet) were missed to be located later by the spotters as they returned through the plots on foot.

The two trees missed on Fremont plot #5, the first of the 11 plots to be cruised, were each large full crowned overmature trees with a volume of 1,740 board feet each. One was killed by bark beetles in 1942 and had a reddish crown. The other was killed about June 1943 and had a decidedly sorrel crown. Both were plainly visible from the road which seemed to indicate that the missing of the trees in the road cruise was a spotting error. The single tree missed on Modoc Plot #12 was a very small one (70 board feet) buried in the midst of a pole thicket and difficult to locate under any circumstances.

It is significant that, in the initial road cruise of the plots, trees were found which had been only recently attacked and which contained some eggs but mostly small larvae. Discovery of these trees was based entirely upon fading of the crowns which occurs rapidly at that time of year. The fading of some of these crowns was scarcely noticeable to any but experienced spotters. Also significant was the fact that the trees which were missed did not occur on plots with a combination of the densest or the tallest ground vegetation.

It is concluded from this test that ponderosa pine trees currently infested with bark beetles can be spotted, under most circumstances, with a satisfactory degree of accuracy by methods ordinarily employed on roadside plots providing the personal error of the spotters is held to a minimum by good training and supervision.

Comparison of Roadside and Rectangular Plot Measurements

The possibility of using roadside plots in conjunction with, or in lieu of, established rectangular plots immediately raises the question of the comparative value of the measurements from these two types of plots. Field measurements from both types have been taken so that this can be answered in several ways; i. e., by comparing the quantitative data obtained from both types of plots by either single measurements or by cumulative periodic measurements.

Table 1. Comparison of spotting performance by riding and walking spotters on roadside plots. Fremont (Oregon) and Modoc (California) National Forests, July 1943.

NATIONAL FOREST	ROAD-SIDE PLOT NO.	NET TIMBERED ACREAGE	PLOT CHARACTERISTICS: TREE SPECIES b.m. VOL. PER ACRE: Pine	Other	GROUND VEGETATION DENSITY	INFRACTED/TREES FOUND: Spotters Riding No.	b.m.	Spotters Walking No.	b.m.
Fremont	4	160	10,000		Low1/	4	3,280	4	3,280
	5	160	15,000		Low	8	12,320	10	15,800
Modoc	12	160	16,000		High2/	4	5,880	5	5,950
	13	80	13,000	13,500	High	2	2,540	2	2,540
	14	160	13,000	13,500	High	8	3,270	8	3,270
	16	80	8,000		High	1	780	1	780
	17	160	8,000		Low	1	180	1	180
	33	160	7,000		Low	3	3,430	3	3,430
	36	80	12,000	6,000	High	4	1,160	4	1,160
	40	160	14,500	8,000	High	0	none	0	none
	41	160	13,000	1,000	High	3	1,790	3	1,790
TOTALS						38	34,630	41	38,180

1/ Shrubs and/or tree reproduction sparse or 6 feet or less in height
2/ Shrubs and/or tree reproduction dense and over 6 feet in height
3/ Ponderosa pine trees killed by bark beetles in 1942 and 1943.

To compare the results of a single measurement from comparable roadside and rectangular plots the Embody and Silver Creek Units of the Fremont National Forest and the Badger Unit of the Modoc National Forest were selected. The forest in both units is quite similar, being composed almost entirely of overmature ponderosa pine of comparable density. Beetle-caused pine mortality had been heavy in both areas for some years and current mortality was considerable at the time of the test, thus offering ample material for measurement. Comparable roadside and rectangular plots had been established and were in operation in both units.

In July 1943 a single cruise was made of each of 16 roadside plots and 8 rectangular plots to determine the number and board-foot volume of ponderosa pine trees killed by beetles from January 1942 to July 1943. The average mortality measured on each of the two types of plots is shown in Table 2 as being very nearly equal. On a per-acre basis, for instance, the number of currently infested trees measured was .038 on the roadside plots and .045 on the rectangular plots and the board-foot volume was 38.0 and 40.4 respectively, a difference of 6 per cent.

The Modoc roadside and rectangular plots used in the above test were cruised for pine mortality annually between 1941 and 1945. Though not too numerous for such a test they do show a comparison, by years, of the mortality which occurred on each of the two types of plots (Table 3). The yearly comparisons of beetle-killed timber, as expressed in volume per acre, are not too close due, perhaps, to a sampling error caused in part to too few infested trees. However, the general trend of timber losses for the 5-year period represented is in general agreement (Figure 4).

The results of these tests, while not too significant, would seem to indicate that there are no inherent features of roadside plots which cause timber mortality measurements to differ greatly from those obtained on comparable rectangular plots. Given the same forest and infestation conditions the measurement of timber losses should average about the same per unit of plot surface regardless of the type of plot.

Area Mortality Estimates Based Upon Roadside Plots

Up to this point the discussion has pertained to tests to determine how effective the roadside plot methods were in measuring beetle-caused timber losses within the plot. Just how effective these plots can be in sampling losses over a fairly large forest area is indicated by a test which compares the average loss per

Table 2. Amount of current[1] beetle-killed ponderosa pine timber cruised on comparable sets of roadside and rectangular plots, July 1943. Fremont (Oregon) and Modoc (California) National Forests.

NATIONAL FOREST	ENTOMOLOGICAL UNIT	SAMPLE PLOTS USED: TYPE OF PLOT	SAMPLE PLOTS USED: NO. OF PLOTS	SAMPLE PLOTS USED: TOTAL TIMBERED ACREAGE	CURRENT BEETLE-KILLED TIMBER: TOTAL NO. OF TREES	CURRENT BEETLE-KILLED TIMBER: TOTAL VOLUME (b.m.)	CURRENT BEETLE-KILLED TIMBER: PER ACRE NO. OF TREES	CURRENT BEETLE-KILLED TIMBER: PER ACRE VOLUME (b.m.)
Fremont	Embody	Roadside	4	1,040	62	73,960	.060	71.1
		Rectangular	3	960	64	67,870	.067	70.7
	Silver Cr.	Roadside	8	3,600	127	120,970	.035	33.6
		Rectangular	2	640	32	20,640	.050	32.2
Modoc	Badger	Roadside	4	640	9	5,870	.014	9.2
		Rectangular	3	920	17	13,360	.018	14.4
TOTAL, ALL UNITS		Roadside	16	5,280	198	200,800		
		Rectangular	8	2,520	113	101,870		
AVERAGE, ALL UNITS		Roadside					.038	38.0
		Rectangular					.045	40.4

1/ Trees killed in 1942 and in 1943 up to July 15.

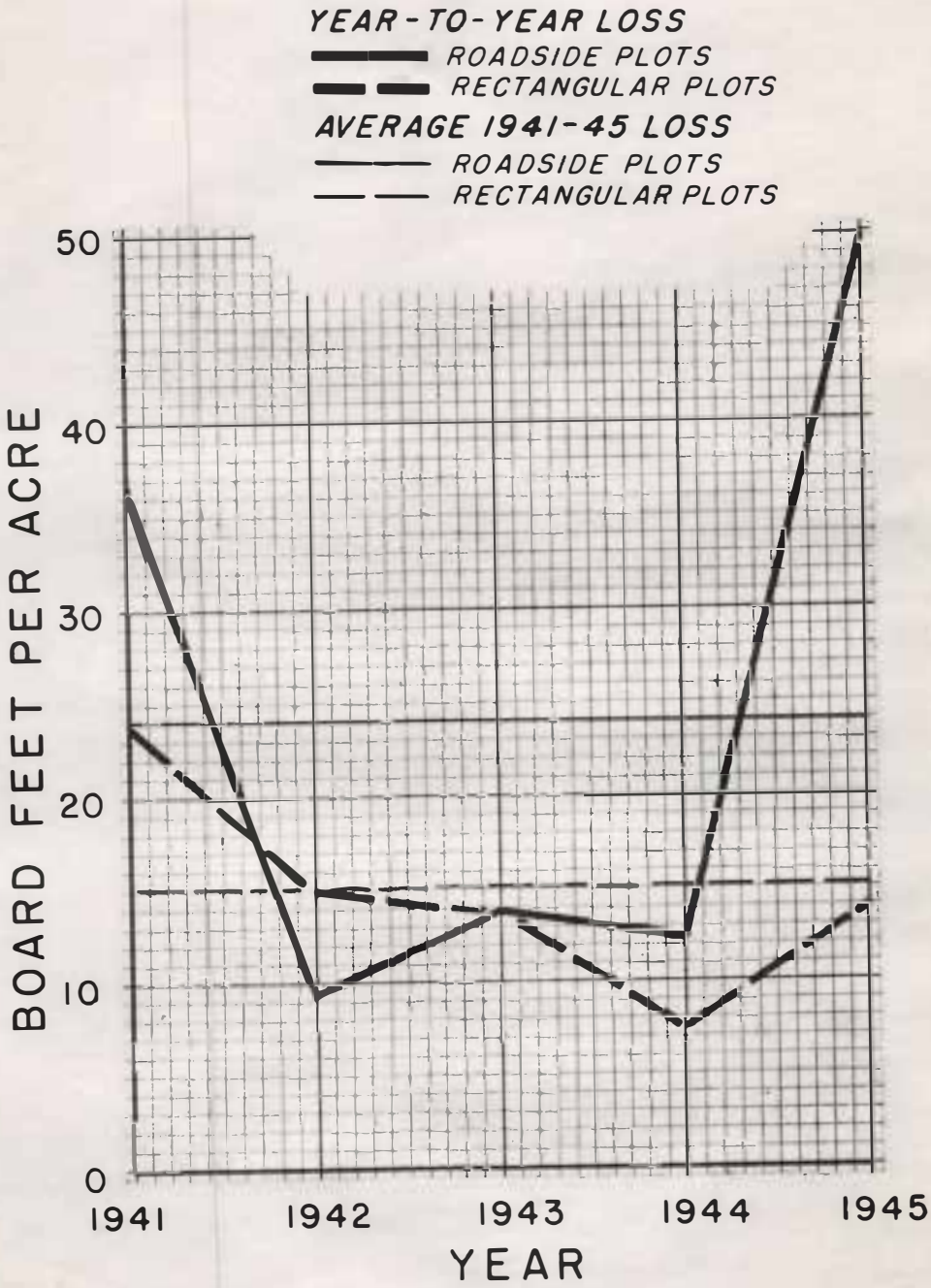
Table 3. Amount of beetle-killed ponderosa pine timber cruised annually on comparable sets of roadside and rectangular plots, 1941-1945. Badger Township, Modoc National Forest, California

YEAR OF LOSS	SAMPLE PLOTS USED: TYPE OF PLOT	NO. OF PLOTS	TOTAL TIMBERED ACREAGE	CURRENT BEETLE-KILLED TIMBER: TOTAL: NO. OF TREES	TOTAL: VOLUME (b.m.)	PER ACRE: NO. OF TREES	PER ACRE: VOLUME (b.m.)
1941	Roadside	4	640	23	23,450	.036	36.7
	Rectangular	3	920	26	21,920	.028	23.7
1942	Roadside	4	640	9	5,890	.014	9.2
	Rectangular	3	920	17	13,360	.015	14.5
1943	Roadside	4	640	7	8,830	.011	13.8
	Rectangular	3	920	11	13,820	.012	13.8
1944	Roadside	3	480	6	5,490	.013	11.4
	Rectangular	2	620	4	4,470	.007	7.3
1945	Roadside	3	480	19	23,840	.040	49.7
	Rectangular	2	620	14	8,600	.023	14.0
5-YEAR AVERAGE	Roadside					.022	24.0
	Rectangular					.017	15.3

FIG. 4

COMPARISON OF CRUISED LOSSES ON ROADSIDE AND RECTANGULAR PLOTS

BADGER TOWNSHIP
MODOC NATIONAL FOREST, CALIFORNIA



acre for a given period from roadside plot measurements to that obtained from a 100 per cent loss survey of an area of which the plots are but a small part.

Data for this test were obtained from the Blacks Mountain Experimental Forest[1] in northeastern California. The combination

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1/ A 9,100-acre forest of mature ponderosa and Jeffrey pine maintained by the California Forest and Range Experiment Station, U. S. Forest Service, to demonstrate the technique and feasibility of certain theories of silviculture, forest management, and insect control which contribute to continuous forest production.

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of a concentrated road system and an intensive annual bark beetle damage appraisal program covering the entire forest made such a test possible. The forest is divided into 100 compartments grouped in such a way as to make up 5 large blocks. Each block is representative of one of several sets of stand and ground conditions found within the forest.

In the bark beetle damage appraisal conducted by the Berkeley Laboratory each year the trees killed during the calendar year are located, examined for insect species and brood condition, measured, blazed, and plotted on spotting maps. These maps, one for each compartment, are drawn to a scale of 16 inches to the mile and show the roads which form parts of the boundary of many of the compartments. From these, it was possible to segregate the trees in each compartment which stood within 5 chains of these bordering roads. By assuming that these trees were properly located on the maps and that they were the trees that might have been marked had the roads been incorporated into a system of roadside plots, it was possible to compare the number and volume of trees on these 5-chain roadside strips with those on the entire compartments.

A better sample was obtained by using the trees killed in 1940 for the test since, in that year, the bark beetle losses in the pine stands on the experimental forest reached a comparatively high level. Only 55 of the 100 compartments in the forest were used for the test, however, since some had been logged as part of insect control or silvicultural cuttings, some were not located along roads, and the roads which bordered others were located in sagebrush flats, draws, or other atypical forest conditions.

The results of this test (Table 4) show that there were 452 ponderosa and Jeffrey pine trees (total volume 557,439 board feet) killed by beetles on the 55 uncut compartments scattered through

Table 4. Comparison of ponderosa and jeffrey pine trees killed by bark beetles in virgin compartment blocks and along roadsides within the blocks. Blacks Mountain Experimental Forest.

BLOCK	ON ENTIRE BLOCK					ALONG ROADSIDES2/ IN BLOCK				
	TIMBERED ACREAGE	TOTAL TREES NO. TREES	TOTAL TREES VOLUME (b.m.)	TREES PER ACRE NO. TREES	TREES PER ACRE VOLUME (b.m.)	TIMBERED ACREAGE	TOTAL TREES NO. TREES	TOTAL TREES VOLUME (b.m.)	TREES PER ACRE NO. TREES	TREES PER ACRE VOLUME (b.m.)
A1/	800.6	38	60,428	.047	75.5	339.3	11	23,132	.032	68.2
B	941.5	127	156,551	.135	166.3	296.1	42	48,981	.142	165.4
C	1,060.8	94	99,747	.089	94.0	299.0	26	26,703	.087	89.3
G	1,206.3	86	126,025	.071	104.5	461.8	36	43,051	.078	93.2
F	995.5	107	114,688	.107	115.2	274.4	28	33,818	.102	123.2
TOTAL	5,004.7	452	557,439			1,670.6	143	175,685		
AVERAGE				.090	111.4				.086	105.2

1/ Basis: Block A; Compartments 18-12, 18-16, 19-19, 19-22, 20-13, 21-10, 21-17, 23-13, 23-19, 25-17.
Block B; " 22-4, 24-4, 24-7, 27-6, 27-11, 29-10, 30-1, 30-3, 30-6.
Block C; " 5-29, 7-21, 7-24, 8-26, 9-18, 9-22, 10-29, 11-19, 11-22, 11-24, 12-26, 13-20, 15-18.
Block G; " 2-12, 2-14, 4-3, 6-19, 7-6, 9-15, 10-1, 17-1, 20-1, 20-6.
Block F; " 18-27, 18-30, 21-28, 23-26, 24-21, 25-19, 28-16, 29-19, 29-21, 29-25 30-17, 31-21, 31-25.

2/ within 5 chains (330 feet) of road

the five blocks of the experimental forest. Of this number, 143 trees (total volume 175,685 board feet) occurred within 5 chains of the roads which formed a part of the boundary of each compartment. Reduced to a per-acre basis for comparison, the number and board-foot volume of trees killed on all compartments averaged .090 and 111.4 respectively and along the roads .086 and 105.2 board feet.

In other words, if the roads had been made a part of a system of roadside plots to sample the pine mortality on the 55 compartments in 1940, the average measured mortality on the plots would have been within 5 percent of the actual number and volume of trees killed on the compartments.

Spotting Time

In 1942 records were kept of the time used in cruising seventy-two 160-acre roadside plots scattered through parts of the Modoc, Shasta, Lassen, and Plumas National Forests in northern California. Obviously, the time increased as the number of infested trees to be marked increased. In plotting time over number of trees (Figure 5) the average cruising time per plot varied from 24 minutes (time to travel 2 miles at 5 m. p. h.) where no infested trees were encountered to 215 minutes (3 hours and 35 minutes) where 64 infested trees were spotted. These times were made with a two-man crew -- a driver and one spotter. All plots were laid out with 5-chain strips on each side of the road. The one spotter, in this case, worked both sides of the road.

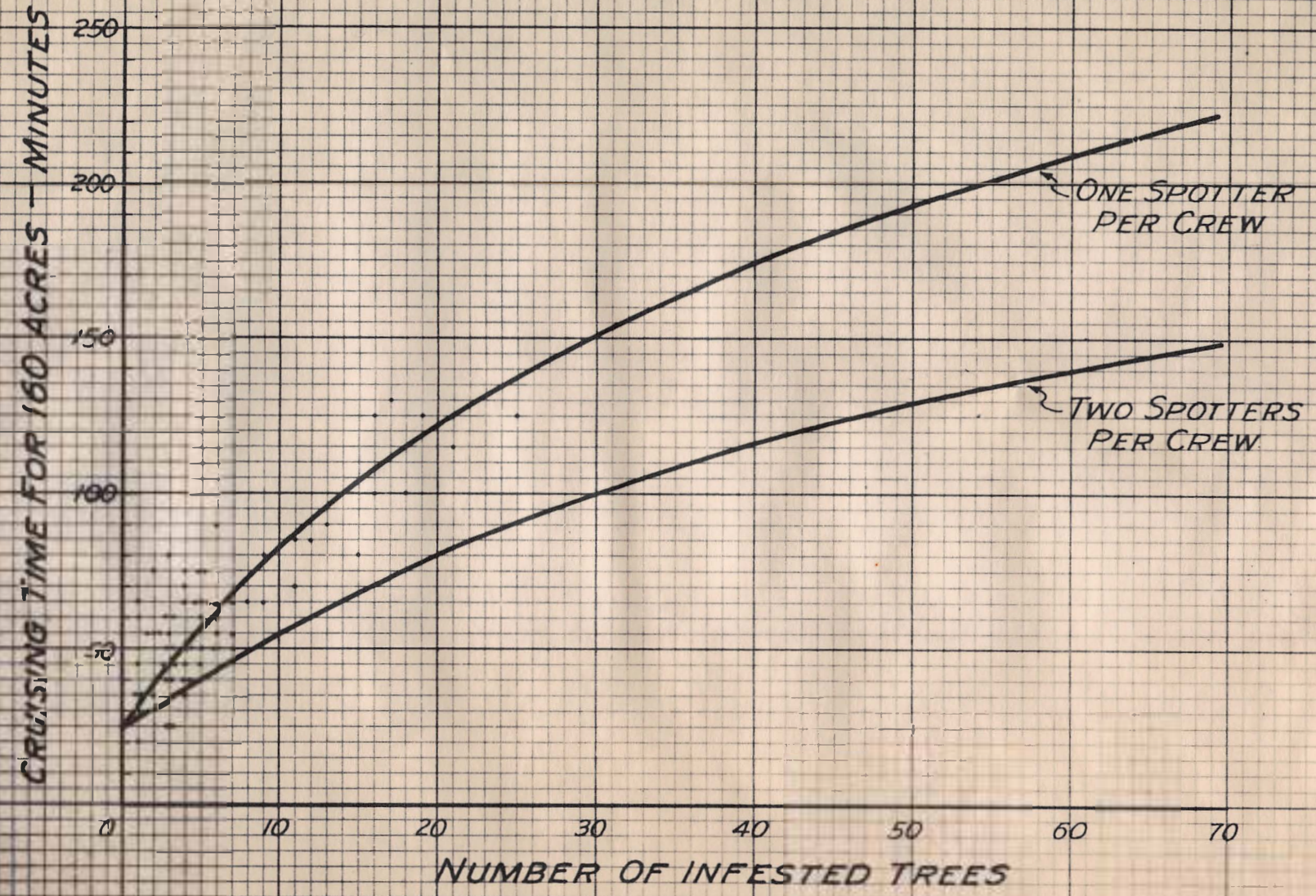
The estimated time for a 3-man crew using two spotters has also been plotted in Figure 5. This has been based upon the assumption that increasing the spotters from one to two would decrease the average spotting time by approximately one-third.

That either curve is not a straight-line value is explained by the fact that as the infested trees become more numerous the spotters spend less time walking between the automobile and each infested tree. Frequently, they can walk from tree to tree in less time than it would take to walk back to the automobile from a tree they had just marked, ride to a point opposite the next tree and pace out to it. This has the effect of reducing the rate of time needed to mark each tree and thus accounts for the flattening out of the curve as the total number of infested trees on the plot increases.

Road Alignment and Gradient

The unimproved "back woods" forest roads which have proven most satisfactory for roadside plots are seldom straight. Because they have been laid out without benefit of any but the most simple grading

FIG. 5 – RELATION OF CRUISING TIME TO NUMBER OF INFESTED TREES ON 160-ACRE ROADSIDE PLOTS



operations they necessarily wind about to take advantage of every little change in topography to hold a uniform gradient. Their crooked nature, however, imposes no great problem in using these roads for roadside plots.

In the standard plot consisting of a 5-chain strip on each side of the road, the plot acreage, under most circumstances, will be the same regardless of whether the road is straight or winding. To illustrate this, some representative roadside plot sections have been reproduced in Figure 6a-c to depict a few alignments which commonly occur in roads. In Figure 6a, for instance, the double line b-b' represents the road and areas aa'b'b and bb'c'c the strips on each side of the road forming a section of a roadside plot. These areas are equal. Together they also equal the area of a plot section of similar width where the road section b-b' is of the same length but perfectly straight. As an example, if b-b' were 50 chains and a-b and b-c each 5 chains, the area of aa'b'b and bb'c'c would each contain 250 square chains, or 25 acres, or 50 acres total. If road b-b' was 50 chains long but straight the two S-shaped areas would then be rectangular in shape though still equalling 25 acres each.

Similarly, in Figure 6b, the J-shaped areas aa'b'b and bb'c'c together total 50 acres if b-b' is 50 chains and a-b and b-c are each 5 chains. In this case, however, the areas aa'b'b and bb'c'c naturally would not equal each other because one is on the outside of a road curve and the other on the inside, thus making their average radii and consequent curved area different. This is compensated for in the S-shaped plot (Figure 6a) but not in the single J-shaped curve.

It is evident from this that S- or J-shaped curves in roads have little effect upon the acreage of roadside plots laid out along them and that, for all practical purposes, the acreage of the plots can be computed from the formula:

$$A = \frac{L \times W}{10}$$

where "A" is the acreage, "L" the length of the plot in chains as measured along the road centerline, and "W" the net width in chains. The formula is intended for plots which lie either to one side or astride of the road.

Figure 6c illustrates a condition of road alignment which does affect the accuracy of roadside plot acreages and which may contribute to false sampling of beetle-killed trees if it is made a part of roadside plots and not compensated for. This is the sharp "hairpin" turn or, in the figure, that part of road b-b' lying between points "d" and "e". These curves usually are a necessity when roads following

ROADSIDE PLOT ALIGNMENTS

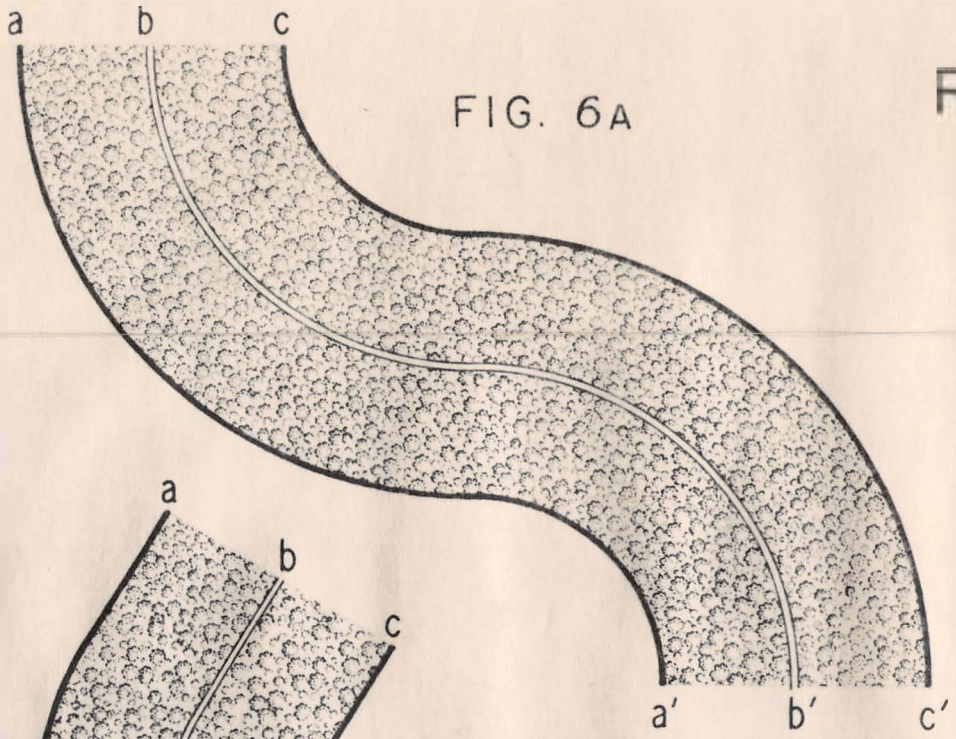


FIG. 6A

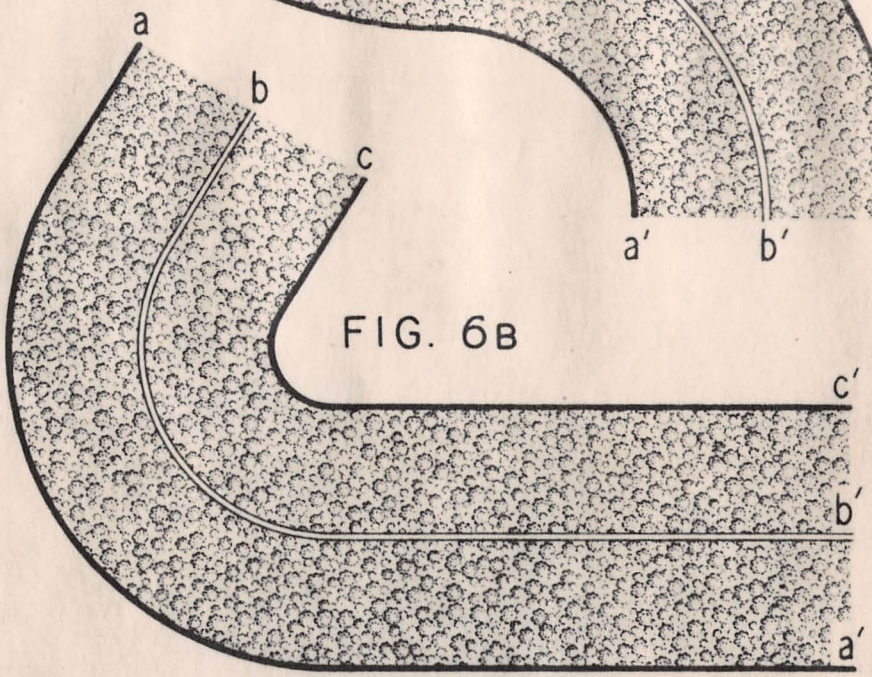


FIG. 6B

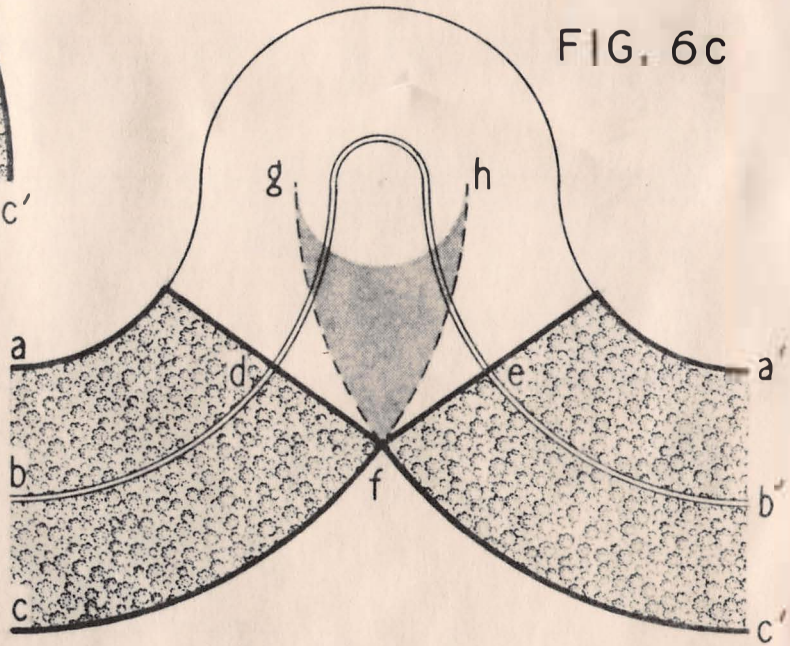


FIG. 6C

hillsides must cross ravines without the help of bridges or high earthen fills. A level crossing is made by having the road follow a contour in and out of the ravine. If the ravine is narrow the road must necessarily double back on itself as it crosses the bottom of the ravine and changes from one hill side to the other via a short radius curve. If the ravine is deep the portions of the road lying on opposite walls of the ravine will often be quite close together for some distance. If the two road sections are less than 10 chains apart (or total roadside plot width) the plot will overlap itself as shown in Figure 6c by the stippled area "fgh". If one of these short radius curves must be included in a roadside plot the simplest means of avoiding this overlapping, and the resultant double cruising, is to break the cruised portion of the plot into two distinct parts by leaving an uncruised gap, or "interruption", between points "d" and "e" on the road. An equivalent distance can then be added to the cruised portion of the plot to maintain a given net plot acreage.

Road gradient, too, may effect the acreage of roadside plots, since their length and the location of points (infested trees, landmarks, etc.) within them depend upon automobile odometer readings. This, in effect, is measuring slope distance whereas the plot location and acreage calculations are based upon land surveys of horizontal distance. If the road is not too steep there is little discrepancy between the slope distance, as measured along the road surface, and the horizontal distance. If, however, much of the road contains gradients of 5 per cent or more, plus or minus, this discrepancy will become great enough to cause error in acreage calculations of the plot. The percentage of error due to this factor is shown in Table 5.

Table 5. Differences in the length and acreage of roadside plots due to road gradient.

Slope of Road (%)*	Vertical Rise Per 1,000 Feet (Feet)	Distance (In Feet)		Acreage		
		Slope	Horizontal	Slope	Horizontal	% of Error
5	50	1,000	995	15.15	15.08	0.5
10	100		985		14.92	1.5
15	150		970		14.70	3.1
20	200		955		14.47	4.7
25	250		930		14.09	7.5
30	300		910		13.79	9.9

* Plus or minus slope

Accuracy of Odometer Equipment

In previous sections it was pointed out that the odometer equipment of the automotive unit plays an important role in establishing new roadside plots or in their subsequent examination. Odometer readings are used to tie in the initial point of the plot with more easily recognized landmarks, to locate the closing point and other landmarks within the plot, and to aid in mapping the location of infested trees. It is important, therefore, that the odometers, whether standard or accessory equipment, be carefully checked for accuracy before using them on roadside plot surveys. Since there may be some error between the recorded mileage and the true mileage this should be checked by special testing equipment or by a series of runs over a measured road course. Once this error is known automotive units can be used interchangeably in making the periodic plot examinations by applying correction factors to the odometer readings. Much of this difficulty can be alleviated by assigning certain automotive units to these surveys and having them equipped with auxiliary survey odometers with appropriate gear ratios to insure accurate mileage readings. These are very accurate in measuring distances as small as 1/100 of a mile.

After odometer equipment is checked and the correction factor, if any, determined it is essential that certain changes not be made in the rear wheel or tire sizes which will change this value. Most odometer equipment is operated directly from the drive shaft of the automobile which means that, with a given number of shaft revolutions, the distance travelled will vary directly with the circumference of the powered tires. The circumference, in turn, varies according to the wheel and tire sizes used or by the degree of tire inflation. The effect of different wheel and tire sizes upon the distance travelled is indicated in Table 6.

DISCUSSION

The foregoing tests point to certain advantages and disadvantages in the use of roadside plots to sample current bark beetle infestations in ponderosa pine forests. Before any conclusions can be drawn concerning the efficacy of these plots an analysis must be made of the factors which favor or limit their use. Some are important while others either are of little importance or subject to correction.

In considering the disadvantages connected with roadside plots first, the most significant might be listed as follows, in the probable order of decreasing importance:

1) Roads. The plots are dependent entirely upon the presence of suitable roads traversing the forested area to be sampled. If there are no roads, or if the existing roads are inadequate, there can be no

Table 6. Effect of tire and wheel size upon the distance travelled by automobiles.

Tire Section (Inches)	Wheel Diameter (inches)	Inflated Tire Size Diameter (inches)	Inflated Tire Size Circumference (Inches)	No. of Revolutions Per Mile	No. Miles Per 720.3 Revolutions	% of Error
5.50	16	27	84.82	746.8	0.96	-4
	17	28	87.96	720.3	1.00	none
	18	29	91.11	695.7	1.04	+4
6.00	16	28	87.96	720.3	1.00	none
	17	29	91.11	695.7	1.04	+4
6.50	15	28	87.96	720.3	1.00	none
	16	29	91.11	695.7	1.04	+4
	17	30	94.25	672.6	1.07	+7
7.00	15	29	91.11	695.7	1.04	+4
	16	30	94.25	672.6	1.07	+7

roadside plots. If the roads which are suitable for this use are poorly distributed throughout the area poor sampling may result. Nothing short of new road construction would correct this situation and this, obviously, is not justifiable for the sake of roadside plot installations alone.

2) New beetle attacks. Newly-attacked trees which have not yet indicated their dying condition by fading of the foliage may be missed by the roadside plot spotters unless they occur close enough to the road that pitch tubes, if any, may be seen. This is most apt to occur during periods when large numbers of new attacks are being made. In the case of the western pine beetle the early summer attack period usually results in more rapid fading whereas fading is somewhat slower following the autumn attack period of this insect. While experienced spotters can detect fading not yet perceptible to the layman they can, and do, miss some of these new attacks. This is not too important if control is not imminent since the overlooked trees can be tallied in the next succeeding cruise of the plot. If late autumn examinations of roadside plots indicate the need for immediate control action, however, then the roadside data may have to be supplemented by a careful tree to tree check by the spotters either on the same plot or on additional sample areas afoot to make certain no newly-attacked trees have been overlooked.

3) Green stand volume. Estimates of green timber volume are more difficult to obtain on roadside plots than on rectangular plots because of the irregular shapes of the former.

4) Spotting accuracy. This is easily affected by the following:

a) Road bias. Trees damaged as a result of abnormal road use attract bark beetles and are apt to cause an unnatural concentration of beetle-killed trees in the vicinity of the roadside plot. Roads newly constructed through dense pine stands often may occasion a "conditioning" period during which the bordering trees may have to adjust themselves to their new environment. Until it can be determined whether trees in this group will survive or succumb from the road construction operation, it is not wise to use the road for roadside plots.

b) Light. Spotting infested trees against the light is just as difficult on roadside plots as on other types of plots. The roadside spotter can overcome this by frequent trips to the edge of the plot to view the trees with the sun at his back or, as is usually done, to remain on the road but to watch the trees on the sunny side while they are yet some distance ~~xx~~ ahead or to the rear of the slowly moving automobile in order to view them in quartering light.

c) Changes in odometer equipment. Switching automobiles on roadside plot surveys may bring into use odometer equipment which does not record travelled distances correctly. This can be overcome by determining the correction factor or by having certain landmarks of known distances along the road used by the plot.

d) Initial plot installation. Errors in spotting results occur from failure to eliminate poor road alignment and gradients or atypical forest areas when setting up new plots.

Inherent advantages of roadside plots can be listed as follows:

1) Cruising time. On a tree per acre basis this is less by far than for an existing sampling medium yielding comparable data. A comparison, for instance, of cruising time needed to mark corresponding numbers of infested trees on 160-acre roadside and rectangular plots, using two spotters in each case, is shown in Table 7.

In addition to the above time actually spent on the plot is the time needed on rectangular plots to walk to and from the nearest road to the beginning and closing corners which may add as much as an hour or more. This time is eliminated altogether in the roadside plot.

2) Travel time. Roadside plots, being smaller, are usually more abundant and hence closer together in a given area than are rectangular plots. The travel time between plots is correspondingly less with the result that a greater part of the roadside plot crew-day is spent in productive cruising time and less in non-effective travel time.

Table 7. Average time required to mark infested trees on 160-acre roadside and rectangular plots.

Number of Trees	Number of Minutes to Mark	
	On Roadside Plots	On Rectangular Plots
0	24	90 - 120
10	55	140
20	80	167
30	100	187
40	116	203
50	130	216
60	140	228
70	150	*
80	*	*
90	*	*
100	260	260

* No observation.

3) Personnel. During periods of normal or subnormal infestations roadside plots can be installed or periodically examined with a 2-man crew instead of the 3-man crew which is the smallest practical crew on a 320-acre rectangular plot. Between 1942 and 1947 roadside plots in northeastern California, numbering approximately 70, were covered quite satisfactorily each year by a 2-man crew. Furthermore, this crew examined an average of three to seven 160-acre plots per day. It is only on rare instances when a 3-man crew, obtaining the same data, can cover more than one 320-acre rectangular plot per day.

4) Sampling. As long as bark beetle infestations continue to be measured by means of selected samples it is believed that better sampling will be achieved by the use of a greater number of smaller plots which are more widely dispersed than the samples used heretofore. The 160-acre roadside plot supplies a means toward this end wherever roads are not a limiting factor. This is chiefly because of their smaller size together with their more rapid and less expensive coverage which, in a given area and with limited funds, allows (1) a larger number of plots and (2) more equable plot distribution not only for the area as a whole but for each stratum or variation in forest or infestation conditions within the area.

CONCLUSIONS

Measurements of beetle-killed pine mortality obtained from roadside plots compares very favorably, qualitatively as well as quantitatively, with those from the rectangular plots heretofore employed

for this purpose. Whenever they can be used their over-all efficiency appears to be much greater as measured by the saving in installation and cruising time and in the smaller field crews needed to operate them than that of other types of plots. This saving is great enough to allow more widespread distribution of the roadside plots which, in effect, increases the sampling efficiency.

Admittedly, there are many localities in the ponderosa pine region where the lack of roads will prevent or limit the use of roadside plots. There are large areas, however, where they can be used unhesitatingly and many others where a careful study of road conditions will show that at least some plots may be used.

One of the greatest benefits, perhaps, to be derived from the development and use of roadside plots is the promise of better bark beetle surveys. Without too much increase in funds existing intensive surveys in some areas can be improved or brought to other commercially important areas where they do not now exist. Once they are established intensive surveys built upon a framework of roadside plots are better able to withstand periods of adversity when funds or personnel are scarce. During World War II this was forcibly demonstrated when, on one 2½-million acre area, beetle surveys each year were actually intensified and extended despite reductions in money and men.

It is believed that these demonstrations of practicability, together with the results of tests of their efficiency, establish the roadside plot as a definite advancement in the technique of sampling bark beetle infestations in situations where it can be effectively used. The preponderance of evidence submitted in this report appears to justify a greater reliance upon roadside plot measurements and to encourage greater use of the plots.

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1. Buckhorn, Walter J. 1944. Instructions for making bark beetle surveys in the virgin ponderosa pine stands of Oregon and Washington. Forest Insect Laboratory, Portland, Oregon. (Mimeographed).

2. Johnson, Philip C. 1936. Field manual of bark beetle surveys, California Region. Forest Insect Laboratory, Berkeley, California. (Mimeographed).

A P P E N D I X

SUGGESTED PROCEDURE FOR THE ESTABLISHMENT AND PERIODIC EXAMINATION OF ROADSIDE PLOTS

Establishing the Plot

The recommended procedure in establishing new roadside plots can be broken down into the following operations:

1. Reconnaissance of area to be sampled
2. Selection of roads suitable for plots
3. Determination of specific location of plots
   a.) Initial point
   b.) Interruptions
   c.) Closing point
   d.) Width
   e.) Boundaries
4. Stand cruise
5. Recording plot description

Reconnaissance. A preliminary study of the timbered area to be sampled by the proposed plot, or plots, is helpful in determining the uniformity of stand and infestation conditions and the characteristics and distribution of the roads. This is important in deciding upon the number of plots needed to sample the area. In general, the more uniform the stand and infestation conditions the fewer plots need be used. If the stand is variable over different parts of the area each variation, or "stratum", should be sampled separately. The number of plots of a certain size which can be used to do this will depend to a great extent upon the availability of suitable roads in each stratum or in the area as a whole.

Selection of suitable roads. To sample infestation conditions in any one stratum the roads within it need to be studied to determine which can be used for roadside plots. Roads satisfactory for this purpose should pass through representative portions of the stand and, in addition, meet the specifications outlined on page 5 of this report.

When suitable roads have been found the next step is to find out which part of them will make the best plots. This usually can be determined after several trial trips up and down each road. A prospective plot site can be considered suitable if (1) the forest conditions are similar in every respect to those which surround it, (2) the atypical forest areas within the plot area are not frequent or extensive enough to cause too many breaks, or interruptions,

in the gross length of the plot, (3) the road alignment and grade is not too tortuous or too steep, and (4) the cross-section topography adjacent to the road is gentle enough and the vegetation of such a character as to permit full visibility from the road to the plot margins on either side. These conditions should remain as uniform as possible along a section of road at least two miles in length and for a distance, if possible, of 5 chains out on each side of the road.

Specific Plot Location. The plot is definitely located by establishing the various component parts which define its limits, and fix its size and area. These parts, illustrated in Figure 1, are the initial point (A); the beginning (B) and ending (C) of interruptions, or atypical areas through which the plot passes; the closing point (D); and the plot width (a-b). The establishment of the initial point more or less fixes the location of the other parts.

The initial point ("A" in Figure 1) may be set anywhere along the road as long as it leaves room for the closing point within the body of timber through which the road passes and which the plot is to sample. It will simplify matters to fix the initial point at some established landmark such as a cattle guard, gate, road or section line intersection. Lacking these, a blazed tree, post or pile of rock at the side of the road will suffice to identify this point. If any of the latter are used the point should be referred to some more permanent landmark so that it can be accurately identified at any time.

The closing point, or distant boundary of the plot ("D" in Figure 1), can be set at any point along the road depending upon the plot acreage desired. Most of the plots in use since 1941 have their closing points placed 160 chains (2 miles) distant along the road from the initial point. If interruptions in timber type (section B-C, Figure 1) occur within this distance the closing point is moved further away so that the distance along the road separating the initial and closing points (A-D, Figure 1) is equal to 160 chains plus the distance, as measured in chains, which the interruption in timber type, (B-C, Figure 1) occupies along the road between these two points.

Plot widths (a-b, Figure 1) are variable, depending chiefly on how well the spotters can be expected to see through the timber stand bordering the road. A good rule to follow in selecting the width of a new plot is this:

1. Use 10 chains (5 chains each side of the road) if:
   a.) timber stand (all species) does not exceed 20,000 b.m. per acre;
   b.) if tree reproduction and brush is sparse and no more than 10 feet high;
   c.) if ground slope at each side of the road does not exceed 30 percent as measured at right angles to road axis.

2. Use 5 chains (2½ chains each side of road) if:
   a.) timber stand (all species) exceeds 20,000 b.m. per acre;
   b.) tree reproduction and brush is dense and more than 10 feet high;
   c.) ground slopes at right angles to each side of road exceed 30 percent.

It may be desirable in some cases, particularly where a road follows one bank of a stream, to place the plot at one side of the road instead of on both sides.

Plot acreages are measured as gross acreage and net acreage depending upon the presence of interruptions in the plot. Referring to Figure 1 again, gross acreage is width in chains (a-b) multiplied by the distance in chains between the initial and closing points (A-D) divided by 10. If there are no interruptions (B-C) this is also the net acreage. Otherwise the net acreage becomes this area less the area of the interruption (width in chains (a-b) multiplied by length of interruption in chains (B-C) divided by 10).

Plot boundaries are not surveyed or marked. The end boundaries at "A" and "D" in Figure 1 are imaginary lines running at right angles to the initial "A" and closing "B" points established on the road. The lateral boundaries are also imaginary lines running a fixed distance from and parallel to each side of the road between points opposite "A" and "D" in Figure1. The spotters must learn to judge the approximate location of the lateral boundaries by eye. Since they pace out to any tree suspected of being infested, any trees near these boundaries can be accurately located with reference to the boundaries simply by pacing out to it. The need for this occurs so seldom that the cost and effort to accurately mark the lateral boundaries would not be justified.

Plot Description. When the initial and closing points, the beginning and ending of interruptions, and the width of a new plot have been located or decided upon, the description of the plot should be entered on the Roadside Plot Data Sheet (Appendix Form 1). The face of the form includes space for all descriptive material relating to the plot location, its dimension and timber resources. On the reverse side is space for a scaled diagram showing the road traverse, the part of the plot to be cruised (net area) or not to be cruised (interruptions), as well as any landmarks which will aid in making subsequent examinations.

Stand Cruise: Estimating the timber stand on a roadside plot may be somewhat more difficult to do by present field techniques because of the irregular shape of the plot. One possible solution is by the use of fractional-acre circular subplots not tied together by ground compass lines, but located by automobile odometer readings and lateral (at right angles to road) pacing. The exact location of these subplots can be predetermined by either random or selection methods.

Periodic Examinations

Each examination begins at the initial point of the plot and is made for the purpose of determining the kind and amount of timber damage on the plot caused by current infestations of bark beetles. The procedure for periodic examinations of the plot resolves itself into the duties of the automobile driver and the spotter, or spotters if more than one is used.

Driver's duties. These are routine once the automobile is spotted at the initial point of the plot. He should be equipped with a copy of the Roadside Plot Data Sheet (Appendix Form 1) for the plot to be examined or cruised. While at the initial point he registers his odometer to read "zero" mileage, if the automobile is equipped with an auxiliary survey odometer, or records the mileage of the standard odometer if it is not.

When the spotter or spotters have taken their working position on the automobile and have signalled their readiness to begin cruising the driver places the automobile in forward motion, and continues at a speed of approximately five miles per hour until the cry of "Bugs!" is heard from the spotters or until the end of the plot is reached. In either case the automobile is stopped and the mileage reading on the odometer is checked.

If the automobile has been stopped to allow a spotter to examine an infested tree, the driver should make certain it has been stopped opposite the tree in question before the odometer

reading is taken. If, upon examination, the tree is found to be infested the driver records its position on the Driver's Form (Appendix Form 2) which is, no more than diagrammatic sketch of the plot. The tree's position is shown by a coordinate system of plotting using the odometer reading (in miles) for the vertical axis and the spotter's paced distance (in chains) from the edge of the road to the tree for the horizontal axis. Tree species symbols and serial numbers used in identifying the tree on the Driver's Form follow the system outlined in current bark beetle survey manuals (1, 2). When the spotter has returned to the Automobile and signalled his readiness to proceed, the driver places the automobile in forward motion again.

Spotter's duties. These are not much changed from the procedure used in examining and marking the infested trees on rectangular plots (1, 2), except that (1) he searches for currently infested trees while riding on a slowly moving automobile, (2) he paces to each infested tree from a point at the edge of the road opposite the tree, (3) the serial number and tree blaze is faced toward the road, and (4) he uses the Spotter's Form (Appendix Form 3) for recording the infested tree data.

Much of the success of the roadside plot spotting depends upon the spotter's position on the moving automobile. He cannot ride inside any automobile equipped with a closed body, but must be outside where a full lateral and overhead view is afforded and, preferably, he must be high enough to see over roadside shrubbery.

At the beginning of each plot examination the spotter takes his working position on the automobile and signals the driver when he is ready to begin cruising. A careful search is made for currently infested trees on the narrow plot as the automobile moves slowly down the road. When one is found or is suspected, the spotter shouts "Bugs" at such a time that the automobile, when stopped, will be directly opposite the tree in question.

The spotter then dismounts and paces out to the tree. He makes the usual examination of the tree to obtain the information needed on his Spotter's Form, blazes and numbers the tree, calls out the number to the driver, and returns to the automobile. He then signals the driver when he is ready to resume cruising.

Since spotting is dependent almost entirely upon foliage color phases, the spotter must be ever alert for the most imperceptible fading shown by newly infested trees. The driver should be stopped at any time to afford closer examination of suspected trees. The spotter, too, must learn to judge the distance from the edge of the road to the lateral boundary of the plot as this will save some time in pacing out to infested trees which are just beyond the boundary.

Safety measures. The proximity of the field crew to moving automobiles requires that certain precautions be taken to prevent injury to the crew members or others using the roads through roadside plots. The following suggestions are offered:

1.) Automotive equipment used for roadside plot examinations should be provided with guard rails, footboards, seats or hand holds to steady the spotter and prevent him from falling while the equipment is moving, stopping or starting.

2.) The spotter's axe should be carried where it will inflict no injury if fallen upon or while the spotter is climbing on or off the automobile.

3.) The automobile should be driven smoothly to avoid sudden starts, stops, changes in pace while shifting gears, and road unevenness which may cause the spotter to fall from the vehicle.

4.) The automobile should be kept out of the way of normal road traffic and never stopped or turned without signalling approaching vehicles.

5.) The spotter should watch for oncoming vehicles before crossing the road to or from infested trees.

6.) The driver should warn the spotter of any overhead or side obstructions which may strike him, such as low hanging tree branches, gates, forest telephone lines, poles, etc.

Cruising Equipment

Driver

Automobile, preferably 1/2-ton pickup truck equipped as in Fig. 3.
Auxiliary odometer
Tatum holder, half letter size
Pencil, 2H or 3H
Rule, 6-inch
Plot Data Forms (filled out), one per plot
Driver's Forms (blank) two per plot

Spotter

Axe, 2½ D.B. or boy's
Biltmore stick
Diameter tape
Lumber crayon, soft black
Pencil, 2H or 3H
Tatum holder, half letter size
Spotter's Forms (blank), two per plot.

Forest Insect Surveys

ROADSIDE PLOT DATA SHEET

PLOT No. L-4

PLOT NAME Nigger Spg.

LOCATION: Forest Lassen ; Area E. Lassen ; Unit Willow Cr.
ACREAGE: Gross 176 ; Timbered 160 . TYPE PP-JP . SITE IV
ESTABLISHED: Date 9/15/42 ; By Eaton, Johnson . MGT. STATUS Virgin

INITIAL POINT On Jellico-Nigger Cabin road at USFS location poster reading "20 chs. S. to Sec. Cor. 1, 6, 11, 10; 1.34 N.; R. 6 E. Run West.

WIDTH: Total 10 chs., 5 chs. each side road ELEVATION: Average 4,500 feet
LENGTH: Total 2.20 miles; Timbered 2.00 miles INTERRUPTIONS: No. of 1
STRIP REPRESENTATIVE OF Virgin PP-JP; Willow Cr. Unit

STAND CRUISE: Date _____ ; Crew _____ ; Percent _____

STAND:	Entire Plot		Average Per Acre		SNAG TALLY:
Species	No. Trees	B.m. Vol.	No. Trees	B.m. Vol.	No. Trees

(OVER)

Appendix Form 1

Forest Insect Surveys
SPOTTER'S FORM

C. B. Eaton
9/15/42

TREES KILLED CALENDAR YEAR 1942

PLOT No. L-4 SHEET No. 1

FOREST Lassen AREA E. Lassen UNIT Willow Cr.

NUMBER	TREE SPP.	KILLED BY	DBH	LOGS	B.M. VOLUME	TREE CLASS DUNN.	TREE CLASS KEEN
1	PP	D.b.	28	5		4	3c
2		Db.-FH	34	6		5	4d
3	JP	D.i.	30	6		5	4c
4		D.i.	26	5		4	3b

Forest Insect Surveys

ROADSIDE PLOT DATA SHEET

PLOT No. L-4

PLOT NAME Nigger Spg.

LOCATION: Forest Lassen ; Area E. Lassen ; Unit Willow Cr.
ACREAGE: Gross 176 ; Timbered 160 . TYPE PP-JP . SITE IV
ESTABLISHED: Date 9/15/42 ; By Eaton, Johnson . MGT. STATUS Virgin

INITIAL POINT On Jellico-Nigger Cabin road at USFS location poster reading "20 chs. S. to Sec. Cor. 7, 8, 17, 18; T.34N.; R.6E." Run West.

WIDTH: Total 10 chs., 5 chs. each side road ELEVATION: Average 4,500 feet
LENGTH: Total 2.20 miles; Timbered 2.00 miles INTERRUPTIONS: No. of 1
STRIP REPRESENTATIVE OF Virgin PP-JP; Willow Cr. Unit

STAND CRUISE: Date _____; Crew _____; Percent _____
STAND: Entire Plot ; Average Per Acre SNAG TALLY:

Species	No. Trees	B.m. Vol.	No. Trees	B.m. Vol.	No. Trees

(OVER)

TRAVERSE: PLOT No. 2-4 ;

0.00	Initial Point
0.60	Stop cruise; begin interruption
0.80	End interruption; resume cruise
1.45	Take right fork
1.95	Cattle guard
2.20	Closing Point

SYMBOLS: To be cruised; not cruised

Forest Insect Surveys
SPOTTER'S FORM

C. B. Eaton
9/15/42

TREES KILLED CALENDAR YEAR 1942

PLOT No. L-4 SHEET No. 1

FOREST Lassen AREA E. Lassen UNIT Willow Cr.

NUMBER	TREE SPP.	KILLED BY	DBH	LOGS	B.M. VOLUME	TREE CLASS DUNN.	TREE CLASS KEEN
1	PP	D.b.	28	5		4	3c
2		Db.-FH	34	6		5	4d
3	JP	D.j.	30	6		5	4c
4		D.j.	26	5		4	3b

Forest Insect Surveys
DRIVER'S FORM

PLOT No. L-4 SHEET No. 1 YR. OF SURVEY 1942
FOREST Lassen AREA E. Lassen UNIT Willow Cr.
DATE 9/15/42 DRIVER Johnson

	Odometer			Odometer	
	1.81	$\Delta \frac{42}{3}$			
$\frac{42}{2}$	1.55				
	0.80 / 0.60	intersection			
	0.33	$\frac{42}{1}$		closing point	
				2.20	
			$\Delta \frac{42}{4}$	2.09	
5 chs.	SCALE	5 chs.	5 chs.	SCALE	5 chs.

Forest Insect Surveys
SUMMARY OF INSECT-KILLED TREES

FOREST_____ PLOT NO._____
TYPE_____ Stand Per Acre TIMBERED
SITE_____ PP_____ JP_____ SP_____ ACRES_____
Other Species_____ All_____

Calendar Year of Loss	Date of Cruise	Loss Per Acre by Tree Species								Remarks
		PP		JP		SP		Total		
		No	Vol	No	Vol	No	Vol	No	Vol	
	Total									
	Total									
	Total									
	Total									
	Total									

(OVER)

Appendix Form 4